Performance Analysis of Solar Still Having Different Plates

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***Abstract*-Solar distillation is one of the important methods of getting clean water from brackish and sea water using the free energy supply from the sun. Here, experiment is made with three identical solar stills. First two solar stills consist of plates like Aluminum and Galvanized Iron. Third solar still is taken as conventional solar still. Performance of solar stills having aluminum plate and Galvanized iron plate is tested and compared with conventional solar still under same climate conditions of Gujarat. It is found from the experiment that, solar still having Aluminum plate increases distillate output of 45 % and Galvanized iron sheet increases upto 15 % compared with conventional solar still.**

Keywords-solar still; Al. Plate - Aluminum plate; GI Plate - Galvanized iron plate; distillate output

I. INTRODUCTION

Drinking water of acceptable quality has become a scarce commodity. In many places of the world only saline or brackish water is available. This leads to an increasing interest in new desalination technologies. The standard thermal methods of water desalination such as multi-stage-flash evaporation and multi-effect-evaporation, vapor compression and reverse osmosis are reliable in the capacity range of some 100 to 50,000 meter cube per day fresh water production. They are not used in regions with low infrastructure either for the supply in decontrols regions due to their permanent need of qualified maintenance and electricity supply. Here the use of solar desalination systems is desirable and makes economic sense [1,2]. Desalination is one of many processes available for water purification, and sunlight is one of several forms of energy that can be used to power the process.

Solar desalination systems can be small or large. They are designed either to serve the needs of single family, producing from 1 to 4 liters of drinking water a day on the average, or to produce much greater amounts for an entire neighborhood or village. In some parts of the world the scarcity of fresh water is partially overcome by covering shallow salt-water basins with glass in green house- like structures. These solar energy distilling plants are relatively inexpensive, low technology systems, especially useful where the need for small plants exists [3]. Different designs of solar still have emerged. The single effect solar still is a relatively simple device to construct and operate. However, the low productivity of the solar still triggered the initiatives to look for ways to improve its productivity and efficiency. These may be classified into passive and active methods. Passive methods include the use of dye or charcoal to increase the solar absorptivity of water, applying good insulation, lowering the water depth in the basin to lower its thermal capacity, ensuring vapor tightness, using black gravel and rubber, using floating perforated black plate, and using reflective side walls [4-6]. Active methods include the use of solar collector or waste heat to heat the basin water, the use of internal] and external condensers or applying vacuum inside the solar still to enhance the evaporation/condensation processes, and cooling the glass cover to increase the temperature difference between the glass and the water in the basin and hence increase the rate of evaporation [7-10].

From above literature reviews, it confirms that, solar still is very important device to convert brackish water into drinkable water. Main aim of this present study is to evaluate effect of various energy absorbing plates in order to improve distillate output of solar stilly through improvement in thermal conductivity. These plates are Aluminum and copper plates in climate conditions of Mehsana Gujarat.

II. EXPERIMENTAL SET UP

In this research work, three solar stills were designed and fabricated to study and compare the performance of the solar stills, as shown in Fig. 1. The first one is a solar still having Aluminum Plate and the second is solar still having Galvanized iron plate while the third is a conventional solar still. The conventional still (a single basin) has a basin area of 1 m2 (50 cm×200 cm). The still is made of iron sheets (2.5 mm thick). The whole basin surfaces are coated with black paint from inside to increase the absorptivity. Also, the still is insulated from the bottom to the sidewalls with sawdust 5 cm thick to reduce the heat loss from the still to atmosphere. The insulation layer is supported by a wooden frame. The basin is covered with a glass sheet 3 mm thick inclined at nearly 30° horizontally. Solar stills put on the terrace of "Geetanjali Society", Mehsana. It has latitude and longitude of Egypt (23 º 43' N, 72 º 37' E) to maximize the amount of incident solar radiation and increases distillate output. The whole experimental setup is kept in the south direction to receive maximum solar radiation throughout the year.

Feed water tank of 50×50×50 cm3 is used to feed water to all solar stills. The feed water tank is connected to the main line which is divided into three feed water lines. A flow control valve is integrated at each line inlet in order to regulate the flow rate of water The experimental setup is suitably instrumented to measure the temperatures at different points of

the still (brine, absorber and glass cover temperatures), total solar radiation and the amount of distillate water. The temperatures have been measured using calibrated copper constantan type thermocouples which were integrated with a modeler programmable logic control (MPLC) to measure all temperatures of the solar stills at the same time. The solar radiation intensity is measured instantaneously by a solarimeter. The digital air flow/volume meter is used to measure the wind velocity. Table 1 shows the different instruments as well as their accuracies used in experiment with solar stills.

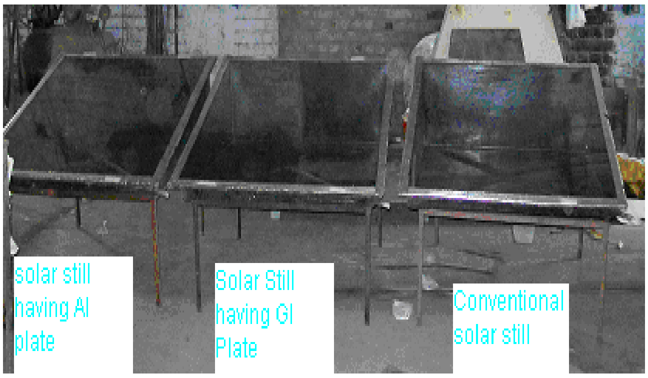

Fig.1. Experimental Set up of Solar stills

TableI EXPERIMENTAL INSTRUMENTS WITH ACCURACY, RANGE AND PERCENTAGE ERRORS

Instrument	Accuracy	Range	% Error
Solarimeter	± 1 W/m^2	0 – 4000 W/m^2	0.5
Temperature Indicator	± 0.1°c	0 – 200 °c	0.5
Measuring Flask	± 1 ml	0 – 5000 ml	1
Anemometer	± 0.1 m/s	0.2 to 40 m/s	1

III. EXPERIMENT PROCEDURE

Experiments of solar stills were conducted at Geetanjali Society, Mehsana, and Gujarat and carried out from 9 a.m to 8 p.m. during July 2011. The solar radiation, atmospheric temperature, basin temperature, glass temperature and distillate water were measured every 1 hour for maintaining steady state conditions. However, the accumulated productivity during the 24 h is also measured in each experimental. All measurements were performed to evaluate the performance of the stills under the climate conditions Mehsana. During the experiments, the ambient climatic conditions (solar radiation, ambient temperature and wind velocity) were also measured.

Saline water in still is heated by solar radiation. The water vapor formed is condensed at the inner glass surface and the water droplets are glided along the glass. The condensed water is collected in a calibrated flask. The depth of the saline water in the solar stills is maintained constant manually using the feed water tank and control valves.

The present experimental study aims to study the effect of still surface area variation on fresh water productivity and the efficiency of basin still at two different cases. The first one is at equalizing the saline water depths inside the three tested stills, while the second case is conducted at equalizing the saline water volume (quantity) in the three tested stills.

IV. RESULT & DISCUSSION

Depending upon the weather conditions of Mehsana, Gujarat, and wind speed is varied from 1.5 to 4.5 m/s at different days of June 2011 and solar insolation is also varied from 30 to 1200 watt/m2. Here solar stills were tested under two cases: At same water depth (4. mm) and same quantity of water (40 L).

Variation of Solar insolation versus Time (Hr) is shown in fig.2. It remains same for all solar stills. Because the solar insolation incident on all solar stills equally. Fig.4 shows basin water temperatures of all solar stills versus Time (Hr). It is shown that, temperatures at all points increased as the time increases till a maximum value during afternoon (because maximum solar radiation fall on earth surface during afternoon, hence maximum value reached at afternoon).It is also observed that maximum value in basin temperature reached during period of 3: 00p.m to 4p.m for all solar still due to great availability of solar radiation as well as warming of solar still from early morning to afternoon. It also shows that, Highest temperature gained by solar still having Aluminum plate compared with solar still having GI plate as well as Conventional solar still. It is increased due to its higher thermal conductivity.

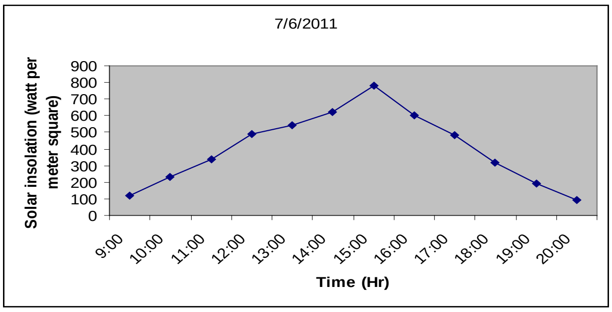

Fig. 2 Comparison of solar insolation and Time Climate conditions of Mehsana (7/06/2011)

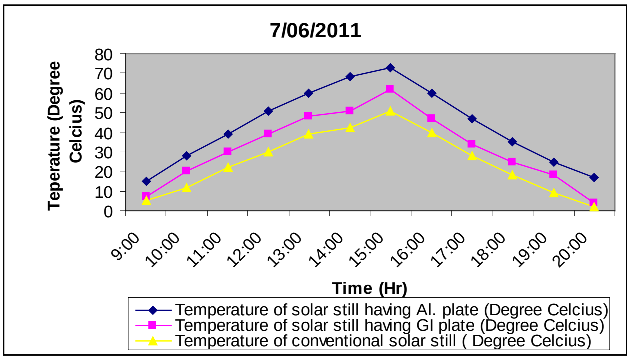

Fig. 3 Comparison of hourly variation of basin water temperature and Time at constant water depth of 40 mm in climate conditions of Mehsana.

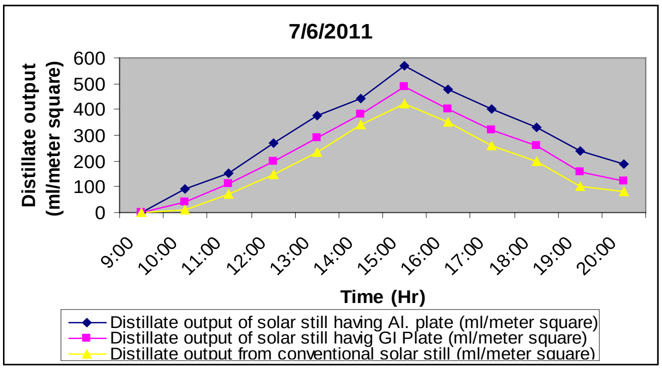

Fig. 4 Comparison of hourly variation of distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana, (07/06/2011)

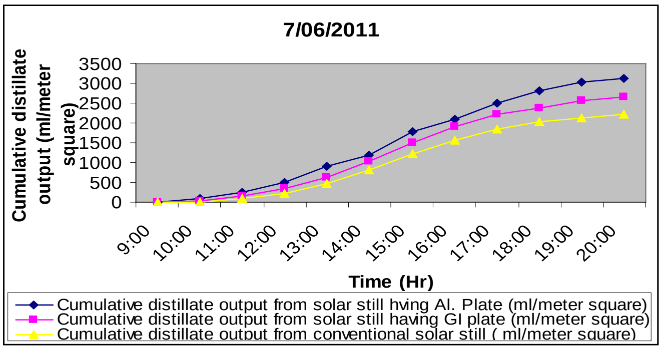

Fig.5 Comparison cumulative of distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana. (07/06/2011)

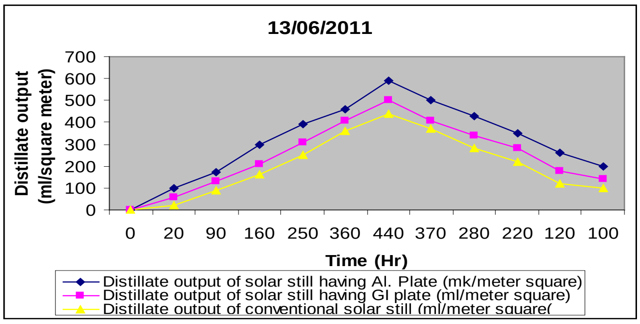

Fig.6. Comparison of hourly variation of distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana. (13/06/2011)

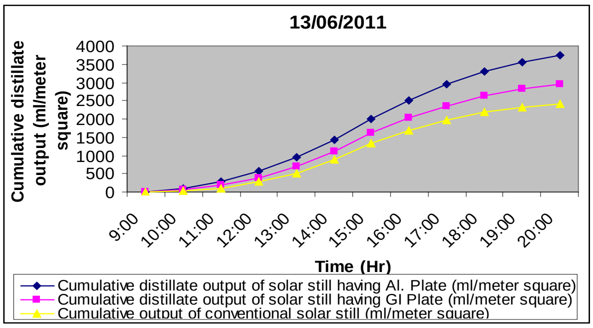

Fig7. Comparison cumulative distillate output and Time at constant water depth of 40 mm in climate conditions of Mehsana (13/06/2011)

Maximum value reached at afternoon).It is also observed that maximum value in basin temperature reached during period of 3: 00p.m to 4p.m for all solar still due to great availability of solar radiation as well as warming of solar still from early morning to afternoon. It also shows that, Highest temperature gained by solar still having Aluminum plate compared with solar still having GI plate as well as Conventional solar still. It is increased due to its higher thermal conductivity.

Fig.3 shows comparison between hourly distillate outputs gained in all three solar stills like solar still having Al. plate, GI plate as well as conventional solar still. It shows that, maximum distillate output gained in afternoon. Also it is observed that, during starting of readings all the readings have initial output at 9 : 00 am is zero then it increased upto 3 pm and then decreases gradually. Here, highest distillate output produced by solar still has Al. plate (20.05 L) because it has lowest quantity of brackish water inside the solar still, so it takes short time for evaporation as well as condensation. Solar still having GI plate has brackish water of (25.20 L) and conventional solar has quantity of (29.50 L). From the quantity of brackish water inside the solar stills, it is shown that, due to large amount of brackish water inside the conventional solar still, it require highest time for evaporation as well as condensation, hence quantity of distillate output produced from conventional solar still is least and highest for solar still having Al. Plate.

TableII COMPARISON OF TESTED SOLAR STILLS OF 40 MM DEPTH OF WATER AS WELL AS 30 L STORAGE OF BRACKISH WATER IN SOLAR STILLS

Date	**Conventional Solar still**	**Solar still having GI Plate**	**Solar Still having**
Distillate output at water depth of 40 mm and Quantity of water 30 L			
7/06/2011	2300	2600	3212
13/06/2011	2410	2970	3500
19/06/2011	2540	3100	3703

Fig.4 shows comparison of accumulated distillate water versus Time for all solar stills. It is shown that, highest accumulated distillate water gained by solar still having aluminum plate and least gained by Conventional solar still.

Table 2 represents the comparison of solar stills at three particular days of June 2011. It shows that improvement in distillate output of 10 % in solar still having GI plate and 40 % of solar still having Al. plate compared with conventional solar still at 7/06/2011.if calculations will be made at 13/06/2011 as well as 19/06/2011, average increase of distillate output of 15 % of solar still having GI plate and 45 % of solar stills having solar still having Al. plate compared with conventional solar still.

V. CONCLUSION

Based on experimental results and discussions following conclusions are made:

- Intensity of solar radiation increases from morning 9 am to 3 pm, then it decreases due to less sunshine hours.

- Higher temperature of solar still always leads to higher distillate output; it is observed in solar still having Aluminum plate.
- Distillate output of solar still having Aluminum plate is higher compared with conventional solar still and Solar still having Galvanized Iron plate.
- Cumulative distillate output of solar still having aluminum plate is higher compared with conventional solar still and Solar still having Galvanized Iron plate. 45 % more output achieved by Solar still having Aluminum plate and 15 % more output achieved by solar still having Galvanized iron plate.

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